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Gravity Equation and Trade Agreements: A Different Econometric Approach

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Abstract

This paper is aimed at multiplicatively estimating the parameters of the gravity equation by using the Poisson Pseudo-Maximum-Likelihood (PPML) estimator, and taking heteroskedasticity into account at the same time. Besides, in order to compare the results, the model will be estimated trough OLS and Tobit, and the precision of the different estimators will be assessed by a set of specification tests. Results indicate that the effects of Preferential Trade Agreements are very sensitive to the method chosen to estimate the gravity model and the results obtained under PPML are the most reliable.

Keywords: Preferential Trade Agreements, Gravity Model, Trade Creation and Trade Diversion, Generalized Lineal Models

JEL Code: F14, F15

RESUMEN

El objetivo de este trabajo consiste en estimar los parámetros de la ecuación gravitatoria en forma multiplicativa utilizando el método de Pseudo Máxima Verosimilitud de Poisson tomando en cuenta al mismo tiempo la heterocedasticidad. Además, y con el fin de comparar los resultados, se estima el modelo por MCO y Tobit y se evalúa la precisión de los distintos estimadores por medio de una serie de tests de especificación. Los resultados arrojan como conclusión que los efectos de los Acuerdos Preferenciales de Comercio son muy sensibles al método que se elija para estimar el modelo gravitatorio y que los resultados obtenidos utilizando PMVP resultan ser los más confiables.

Palabras clave: Acuerdos Preferenciales de Comercio, Modelo Gravitatorio, Creación y Desviación de Comercio, Modelos Lineales Generalizados.

Clasificación JEL: F14, F15

I. INTRODUCTION

The gravity model applied in international trade is based on the assumption that trade between two countries is directly related to size (usually measured in terms of domestic product and population) and, inversely, to transaction costs (distance, adjacency, no common language). It has been extensively used to quantify the effects of trade integration agreements given its advantage concerning the possibility of separating such effects from other factors which are also of relevance in international trade. The application of the gravity model has been possible by using cross section, panel, pool and other data. The studies conducted on the theoretical foundations of this model reflect that it is not possible to state that the gravity equation responds to a particular international trade model (Anderson, 1979; Bergstrand, 1985; Helpman and Krugman, 1985; Deardoff, 1995; Evenett and Keller, 1998 and Anderson and Mercoullier, 1999).

Not taking into consideration the theoretical foundation aspects, the empirical success of the gravity equation is based on its ability to incorporate most of the phenomena occurring in international trade: growing trade volumes between industrialized countries, intra-industrial trade, trade liberalization adjustments, relationship between a country's size and its exports, and others (Sá Porto, 2002).

In the case of Mercosur, a number of studies have analysed different aspects: sectoral exports and distance (Martínez Zarzoso and

Nowak-Lehman, 2002); trade flow determinants (Martínez Zarzoso and Nowak-Lehman, 2003) and openness and trade liberalization (Azevedo, 2001 and Carrillo and Li, 2002). In an attempt to measure the effects of Mercosur for Argentina, in a dynamic approach, Recalde and Florensa (2006) considered the impact on the trade of manufactured goods.

Most of the empirical works, however, have estimated the parameters of the gravity model by log-linearizing it and then using the Ordinary Least Squares (OLS) or the Tobit method without analysing the effects of the presence of heteroskedasticity in the data on the reliability of the estimates obtained.

Considering the last mentioned aspect, the purpose of this work is to estimate the parameters of the gravity equation multiplicatively by using the Poisson Pseudo-Maximum-Likelihood (PML) technique. Also, in order to compare the results, the model will be estimated using the OLS and the Tobit methods; the accuracy of the different estimators will be assessed with different specification tests.

Five separate sections are developed in this paper. After the Introduction, in Section II the evolution of the functional form of the gravity model and the estimation methods used are dealt with to account for the model adopted; the corresponding data are introduced in Section III while Section IV contains the estimates for the parameters. The final section offers the conclusions.

II. Evolution of the Gravity Model

II. a. Functional Form

Two groups of models are available to analyse the effects of a trade integration agreement statically[1] (Sá Porto, 2002): those which measure ex-ante the effects of a trade agreement between member countries (general equilibrium models, those that consider price elasticities, and others) and the groups which estimate the ex-post effects, that is to say, the effects occurring after integration has taken place. The gravity equation is relevant in relation to the latter group.

The gravity model used to measure trade flows first appeared in the 1960s with the contributions made by Tinbergen (1962), Pöyhönen (1963) and Linnemann (1966). These authors originally determined the

1. See Sanz (2000, 2001) and Recalde and Florensa (2006) with respect to the effects of economic integration measured dynamically.

explanatory variables of the trade flows between two countries in relation to three factors: a) those linked to the potential supply of the exporter country; b) those related to the potential demand of the importer country and c) those associated with natural or artificial trade resistance. The explanatory variables generally used were: each country's GDP (trade between two countries is expected to rise in relation to the size of those countries and, therefore, the product may be a good proxy), the per-capita GDP of the exporter and the importer countries (the higher the development level the higher the variety of the goods supplied and demanded) and the distance between each pair of countries serving as resistance proxy. The import tariffs, the quantitative restrictions, the exchange rate controls, and others may be taken as part of the artificial resistance measures; they have not been considered here because such information was unavailable for the countries under consideration.

The functional form of the gravity equation would, then, be

$$M_{ij} = \beta_0 Y_i^{\beta_1} Y_j^{\beta_2} \left(Y_i / N_i\right)^{\beta_3} \left(Y_j / N_j\right)^{\beta_4} D_{ij}^{\ \beta_5} \eta_{ij} \qquad (1)$$

where

M_{ij} : nominal imports from country *i* to country *j*

Y_h: nominal income of country *h* ($h = \{i, j\}$)

N_h: population of country *h* ($h = \{i, j\}$)

D_{ij}: distance between countries *i* and *j*

η_{ij}: error term

Along with the main variables, later applications of the gravity model contributed to the identification of additional variables which promote or discourage bilateral trade and, consequently, it was possible to improve the explanatory force of the model used. Also, mention must be made of the isolation or relative distance of a country, defined as the weighted average of the different distances separating the trade partners, where each country's participation in the world product is used as weights[2]. If the estimation shows a positive sign, then two countries away

2. Polak (1996) states that the use of absolute distances cause downward biases (positive residuals) for the distantly located countries, and upward biases (negative residuals) for the countries geographically closer. The way to solve this difficulty is to add the relative distance.

from other countries will trade between them more widely than the case of two other countries located at the same distance but geographically surrounded more closely by numerous trade partners.

Significant dummy variables were also taken into account. Among the most important ones are: adjacency, which makes reference to the chance two countries may share geographical limits; common language, which measures whether two countries with the same national language tend to trade between them and, finally, the variable used to reflect whether a country is landlocked. It is expected that the estimation of the parameters for the adjacency and common language variables show positive sign, while in the case of a landlocked country, the estimates would be negative. In the latter instance, the positive sign would show that the landlocked countries trade less than those which possess an outlet.

If we take Δ_{ij} as the second member of the equation (1), the augmented specification of the gravity model would be:

$$M_{ij} = \Delta_{ij}\, R_i^{\beta_6}\, R_j^{\beta_7} \exp(\beta_8 adjac + \beta_9 lang + \beta_{10} out_i + \beta_{11} out_j) \qquad (2)$$

where

R_h: remoteness or isolation of country h ($h = \{i, j\}$)

adjac: dummy with value 1 if countries i and j share geographical limits

lang: dummy with value 1 if countries i and j share a common language

out_h: dummy with value 1 if country h is landlocked ($h = \{i, j\}$)

Equations (1) and (2) represent the so-called “antimonde”; they explain bilateral trade between countries i and j in the case neither of them be a member of a Preferential Trade Agreement (PTA). The mentioned equations help to estimate the trade volume held “normal” between i and j, that is to say, before the absence of any kind of preferential agreement.

The gravity model, because it may explain trade flows, has also been used quite widely to estimate the effects of the PTAs on trade patterns. This feature is perhaps what makes it convenient with respect to some analytical models which require a more explicit identification and modelling of each change observed during the integration process. It should also be mentioned that there was evolution in the way of measuring the integration effects.

A dummy variable capturing the effects of a PTA on the intra-bloc trade was added in the first empirical applications, the sum of the trade creation and deviation concepts as introduced by Viner. If the coefficient associated with the variable is positive and significant, then the PTA is a gross trade creation. Aitken (1973), by using cross sections, estimated the effects caused by the European Economic Community (EEC) and the European Free Trade Association during the 1951-1967 period.

Later, another dummy variable was added, which captures the effects on third countries of the creation of a bloc. In the case of an intra-bloc trade increase, this variable seeks to determine whether such increase occurs at the expense of other countries. Then, a significant and positive coefficient of the intra-bloc variable plus a non-significant coefficient of the extra-bloc variable indicate trade creation; if the coefficient of the latter variable is negative and significant, then, there would be trade deviation.

Soloaga and Winters (2001) introduced an additional refinement in measuring the effects of the PTAs when three dummies are taken: one for intra-bloc trade, one for a bloc's total imports (imports openness) and the third one for a bloc's total exports (exports openness). If the exports dummy coefficient is negative and significant, there would be evidence of exports deviation, where the member countries would deviate exports destined to third countries to the member countries. Then, if the imports and exports dummies coefficients are negative, there has been trade deviation, while the sum of the coefficients of the three dummies render gross trade creation, both following Viner. The authors point out that the use of the three dummies help to consider the fact that the trade agreements may have been accompanied by unilateral trade liberalizations on the part of the member countries. The models based on the residuals cannot separate the integration effects from other changes which may have occurred simultaneously (Azevedo, 2001).

Using the Soloaga and Winters' proposal and following what has been above mentioned to measure the effects of the PTAs, the structure of the gravity equation would be

$$M_{ij} = \Theta_{ij} \exp\left(\sum_{k \in PTAs} \beta_{ik} B_k + \sum_{k \in PTAs} \beta_{mk} I_k + \sum_{k \in PTAs} \beta_{mk} X_k \right) \tag{3}$$

where

Θ_{ij} : is the second member of equation (2), i.e., the *antimonde*

B_k: the intra-bloc corresponding to the PTA k

I_k: the dummy identifying whether the importer country belongs to the PTA k

X_k: the dummy identifying whether the exporter country belongs to the PTA k

Consequently, the equation to be estimated is

$$\begin{aligned} M_{ij} = {} & \beta_0 Y_i^{\beta_1} Y_j^{\beta_2} \left(Y_i/N_i\right)^{\beta_3} \left(Y_j/N_j\right)^{\beta_4} D_{ij}^{\ \beta_5} \mathrm{R}_i^{\beta_6} \mathrm{R}_j^{\beta_7} \\ & \cdot \exp(\beta_8 adjac + \beta_9 lang + \beta_{10} out_i + \beta_{11} out_j) \cdot \\ & \cdot \exp\left(\sum_{k \in PTAs} \beta_{ik} B_k + \sum_{k \in PTAs} \beta_{mk} I_k + \sum_{k \in PTAs} \beta_{mk} X_k \right) \eta_{ij} \end{aligned} \tag{4}$$

II. b. Estimation Methods

The estimation strategy used in most empirical works already mentioned above consisted in linearizing the multiplicative form of the gravity model, applying the natural logarithm to both members of equation (4) and, then, estimating the parameters of the model following the log-linear form by using the ordinary least squares. However, there are drawbacks associated with the procedures described formerly.

The first difficulty is related to the nature of the endogenous variable. Since the gravity model applications, in general, use a large number of countries and/or years, there are certainly pairs of countries which do not trade between them. This way, different observations rise for which the dependent variable (exports or imports) assumes zero value, and the logarithmic transformation is, then, not possible. Different alternatives have been developed to face this problem. The first one, adopted, for example, by Wang and Winters (1992) and by Frankel and Wei (1993) consists in ruling out the zero bilateral flows[3]. Another possibility is to

3. This procedure would not consider why very low trade levels have occurred and may lead to biased estimates.

replace the zero value with a very small one, as, for example, 0.1 or 1, before taking the logarithms, as do Linnemann (1966) and Kume and Piani (2000). The problem with both alternatives is that they are ad-hoc procedures and, therefore, not based on any theoretical argument.

A third alternative is to apply a Tobit model; for example, Soloaga and Winters (2001) and Azevedo (2001), who take into account the fact that the dependent variable is censored for a determined percentage of the observations. Nevertheless, the Tobit model continues to be log-linear for the observations where the endogenous variable is strictly larger than zero.

It must be mentioned that Sanso et al. (1993) showed that the specification in logarithms not necessarily is the best functional form but represents a particular case of the Box-Cox transformation. Using this argument, the works by Sanz (2000, 2001), Recalde and Florensa (2005a, 2005b, 2006), among others, estimated the gravity model along with the optimum transformation parameters. However, the trouble with the Box-Cox parameter is that being a non-linear transformation, it does not allow to recover the conditional expectation estimation of the bilateral trade flows.

The second drawback associated with the log-linearization of the gravity model is related to the heteroskedasticity present in the trade data. Both the OLS and the Tobit method produce consistent estimates to the extent that the error term be homoskedastic. To clearly understand the consequences of heteroskedasticity, take the following example, which has been simplified to illustrate this issue: be y the dependent variable, x the independent one[4] which are related by means of this multiplicative model

$$y = \exp(\beta x)\eta \tag{5}$$

where η stands for the error. Let us assume this is heteroskedastic, i.e, $\eta = f(x)$.

4. The independent variable is expressed in logarithmic scale.

If the natural logarithm in both members is taken, the conditional expectation given x is

$$E(\ln y|x) = \beta x + E(\ln f(x)) \tag{6}$$

therefore, βx is an inconsistent estimation of E (In|yx).

Not to have the difficulties mentioned, it is necessary to estimate the model multiplicatively but considering heteroskedasticity. One procedure may be by using the Generalised Linear Models (GLM) introduced by Nelder and Wedderburn (1972).

When modelling by using the GLM, the expectation and the variance of the endogenous variable must be specified, conditioned to the exogenous variables. Particularly, a conditional expectation is proposed exponentially

$$E(y|x) = \exp(\beta x) \equiv \mu(x;\beta) \tag{7}$$

With respect to the conditional variance, the following class of power-proportional variance functions is suggested

$$v(y|x) = \tau\,(\mu(x;\beta))^{\theta} \tag{8}$$

with $\tau > 0$ and θ non negative and finite. It may be seen that (8) includes homoskedasticity as well as certain heteroskedasticity patterns.

The estimation of the conditional expectation parameters, in the mentioned case β, is reached by using the Generalised Estimating Equations, which lead to the moment or quasi-score equations

$$\sum_{i=1}^{N} \left(\partial\mu(x_i;\beta)/\partial\beta\right)\left(v(y_i|x_i)\right)^{-1}\left(y_i - \mu(x_i;\beta)\right) = 0 \tag{9}$$

where the solutions $\hat{\beta}$ are the desired estimators.

If it is assumed that $v\,(y|x) \propto \mathrm{E}(y|x)$, (9), then,

$$\sum_{i=1}^{N} x_i (y_i - \exp(\beta x_i)) = 0 \qquad (10)$$

Santos Silva and Tenreyro (2006) follow this approach to estimate the parameters of a simple gravity model multiplicatively, using the 1990 data; they noticed that the estimator that meets (10) is numerically equivalent to the estimator of the Poisson Pseudo Maximum Likelihood (PPML) suggested by Gourieroux, Monfort and Trognon (1984b) for count data.

An advantage of the PPML estimator is that it is consistent even if the conditional variance is not well specified[5]. The only consistency requirement is found in the correct specification of the conditional expectation.

III. THE DATA

The information used covers the total international bilateral trade flows of 126 countries[6] for 1990-2000. Therefore, there is a total 126x125x11 = 173250 observations, of which 80376 are no zero.

The data related to trade flows were obtained from the International Trade Data (NBER-UN World Trade Data 1962 – 2000)[7]. For Paraguay, the only country without available data, the Base de Datos de Comercio Exterior (International Trade Data Base, BADECEL) of CEPAL[8] provided the required data.

The source for the data on Population and Gross Product was the World Bank's World Development Indicators Online (WDI).

Distance was calculated following the "great circle" formula, taken from longitudes and latitudes of each country's capital city. The common language dummy, the adjacency dummy (common frontiers) and the landlocked dummy were obtained from the data base for the CEPII gravity models[9].

5. Gourieroux, Monfort and Trognon (1984a)

6. Annex I contains the list of countries involved.

7. Feenstra, R. et al. (2005).

8. Available on www.eclac.org/badestat/

9. Available on http://www.cepii.fr/anglaisgraph/bdd/distances.htm

The dummy variables corresponding to the MERCOSUR, EUROPEAN UNION, NAFTA, CER and CARICOM blocs are the authors' elaborated data, and the remoteness was calculated according to Wei (1996) as follows

$$R_i = \sum_j w_j * dist_{ij} \tag{11}$$

where $dist_{ij}$ is the geographical distance between country i and country j, and where $w_j=Y_j/\sum_i Y_i$ for all $i \neq j$; likewise for country j.

IV. EMPIRICAL APPLICATION

To reach the purpose stated in the introduction, the gravity model in equation (4) will be estimated using the bilateral flows data of the 126 countries for 1990-2000. The blocs to be taken in this work are: MERCOSUR, EUROPEAN UNION, NAFTA, CER and CARICOM[10]. It must be noted that the imports openness dummy measures the extent to which the imports of the members of a given bloc are larger than those predicted by the *antimonde* in equation (2); the exports openness dummy quantifies to what extent the exports of the members of a bloc, destined to all countries, are larger than expected. Finally, the intra-bloc dummy captures the effects of the bloc which exceeds imports and exports.

Instead of estimating the model by using cross sections, the data will be grouped and only one regression will be estimated. This decision will help to obtain more reliable and more efficient estimates with greater degree of freedom.

To determine the effects of heteroskedasticity on the estimators, apart from the PPML method, the results of two alternative techniques, widely known in the literature, OLS and Tobit, are introduced. Particularly, the OLS are used for the gravity equation logarithmically, with $\ln(M_{ij})$ and $\ln(1 + M_{ij})$ as endogenous variables and the Tobit model with $\ln(1 + M_{ij})$ as dependent variable. To determine which group of estimates is more reliable, the results are submitted to two specification tests.

The estimates obtained with the techniques mentioned are shown in Table 1. Column 1 shows the OLS estimates by using the log dependent

10. See Annex II

variable. The second column contains the OLS estimates of the log of $(1+M_{ij})$, an ad-hoc procedure used not to eliminate the observations with the dependent variable equal to zero. The third column presents Tobit estimates based on log of $(1+M_{ij})$ as dependent variable. The last column shows the estimates obtained with PPML.

Table 1

Gravity Model Estimates

ESTIMATOR: DEPENDENT VARIABLE:	OLS1 In (M_{ij})	OLS2 In$(1+M_{ij})$	TOBIT In$(1+M_{ij})$	PPML M_{ij}
Log importer's GDP	0910 (0.004)	1.191 (0.005)	2.243 (0.009)	0.797 (0.010)
Log exporter's GDP	0.818 (0.004)	1.001 (0.005)	1.907 (0.009)	0.760 (0.008)
Log importer's GDP per capita	0.167 (0.005)	0.168 (0.007)	0.284 (0.012)	0.114 (0.017)
Log exporter's GDP per capita	0.152 (0.005)	0.187 (0.007)	0.328 (0.012)	0.155 (0.012)
Log distance	-0.941 (0.010)	-0.653 (0.012)	-1.157 (0.022)	-0.473 (0.018)
Log importer's remoteness	0.653 (0.024)	-0.016• (0.044)	0.408 (0.082)	0.707 (0.082)
Log exporter´s remoteness	1.503 (0.034)	0.833 (0.044)	1.808 (0.082)	0.743 (0.086)
Adjacency dummy	0.399 (0.043)	0.086• (0.057)	-0.454 (0.105)	0.427 (0.042)
Common-language dummy	0.467 (0.017)	0.692 (0.020)	1.388 (0.399)	0.310 (0.043)
Landlocked-importer dummy	-0.273 (0.019)	-0.391 (0.021)	-0.662 (0.043)	-0.295 (0.038)
Landlocked-exporter dummy	-0.525 (0.019)	-0.474 (0.021)	-0.934 (0.043)	-0.251 (0.046)
MERCOSUR intrabloc dummy	0.716 (0.203)	-0.056• (0.269)	-0.259• (0.455)	1.495 (0.084)
MERCOSUR imports dummy	-0.717 (0.037)	-1.320 (0.045)	-2.714 (0.085)	-0.958 (0.049)
MERCOSUR exports dummy	-0.747 (0.039)	-0.889 (0.045)	-1.935 (0.081)	-1.134 (0.045)
NAFTA intrabloc dummy	0.902 (0.199)	1.190 (0.373)	-1.860 (0.580)	-0.082• (0.102)
NAFTA imports dummy	0.050• (0.032)	0.692 (0.052)	-0.602 (0.085)	0.297 (0.041)
NAFTA exports dummy	0.336 (0.032)	0.004• (0.052)	-1.827 (0.085)	-0.109 (0.048)
EU intrabloc dummy	0.050• (0.430)	-1.340 (0.071)	-5.611 (0.114)	0.852 (0.049)
EU imports dummy	0.175 (0.021)	1.885 (0.032)	2.165 (0.055)	-0.558 (0.052)
EU exports dummy	0.048 (0.021)	1.545 (0.032)	1.851 (0.055)	-0.424 (0.043)

Table 1

Gravity Model Estimates (continued)

ESTIMATOR:	OLS1	OLS2	TOBIT	PPML
DEPENDENT VARIABLE:	In (M_{ij})	In(1+ M_{ij})	In(1 +M_{ij})	M_{ij}
CARICOM intrabloc dummy	-0.164• (0.228)	-0.568 (0.104)	-2.697 (0.321)	0.141• (0.273)
CARICOM imports dummy	-0.106 (0.032)	-0.056• (0.03)	-0.343) (0.066)	-0.481 (0.092)
CARICOM exports dummy	-0.014• (0.029)	0.053• (0.03)	0.125# (0.063)	-0.115• (0.064)
CER intrabloc dummy	1.680 (0.334)	2.974 (0.64)	-0.021• (0.992)	1.546 (0.087)
CER imports dummy	-0.889 (0.042)	0.255 (0.065)	-0.189• (0.075)	-0.841 (0.081)
CER exports dummy	-0.570 (0.044)	-0.001• (0.065)	-0.405 (0.111)	-0.662 (0.069)

denote significance at 95%

• Non significant variable

Variables without any symbol denote significance at 1%.

The GDP estimates of the importer and exporter countries have the expected sign with all the methods used. However, the PPML estimates are smaller than the OLS and Tobit estimates. In particular, with OLS2 and Tobit, estimates larger than 1 are obtained, which would indicate that the countries with a bigger GDP tend to be more open than those with a smaller GDP. This contradicts the stylised facts of international trade; therefore, both OLS and Tobit tend to overestimate the effects of the GDP on trade flows.

Considering the per capita GDP, the estimates show the expected sign and, again, the values obtained with OLS and Tobit are higher than those obtained with PPML.

With respect to the distance variable, although it throws the sign expected and obtained with all the methods, it is less significant with PPML. The greatest overestimation is linked to the Tobit, followed by the

OLS1. Then, transport costs would represent a lesser drawback to trade than it is generally assumed.

Almost all the remoteness variable estimates show positive sign for both importer and exporter countries; the only estimation with negative sign is non statistically significant. However, the marked asymmetry between the values obtained for importer and exporter countries as evidenced in OLS1 and OLS2 and Tobit contrasts with the similitude of the PPML estimates.

The estimates of the adjacency dummy variable show the expected sign except the one by using Tobit. Only the estimates obtained with OLS1 and PPML are significant and similar among the estimates with the correct sign.

With respect to the language dummy, all the estimates present the correct sign, although with great variability. For instance, with PPML, the countries enjoying the same language on average trade some 36% more; if Tobit is used, the conclusion would be that they trade almost three times more[11].

The landlocked dummies show the expected sign in all the estimates although, in this case, the greater effect is obtained with Tobit, and the lesser with PPML. With the latter method, the importer country with no outlet to the sea would trade some 25% less, on average, than a country that enjoys such exit. For an exporter country, this percentage is a little less (22%). Again, the estimates obtained for both importer and exporter countries are virtually the same only if PPML is used.

Considering now the estimates associated with the dummies that measure the effects of the different blocs, it may be observed that the PPML shows intra-bloc trade creation in all the cases when the coefficient is statistically significant; this is to say, for MERCOSUR, EU and CER. With OLS1, a significant intra-bloc trade creation is reached for MERCOSUR, NAFTA and CER. For OLS2, the coefficient is not significant only for MERCOSUR, but significant and with positive sign for NAFTA and CER, and negative for EU and CARICOM. Finally, using Tobit, the coefficients are significant only for NAFTA, EU and CARICOM, all with negative sign. The fact that the coefficients are high is striking; it would mean an intra-bloc trade destruction of 84% for NAFTA, of 99% for the EU, and of 93% for CARICOM. Such results appear as little credible.

11. The formula used is: $(e^{\text{coef.dummy}} - 1) \times 100$

Taking imports openness, it is seen that the dummy coefficient is negative with the four methods used for MERCOSUR and CARICOM. Instead, for NAFTA it is significant only with OLS2, PPML and Tobit: positive with the first two and negative with the last one. For the EU, the coefficient is negative only with PPML. The CER coefficient is negative and significant with PPML and OLS1 while it is positive and significant with OLS2.

Lastly, in relation to exports openness, the estimates with PPML show negative sign for all blocs and non significant only for CARICOM. Then, using PPML, it may be deduced that all blocs have had exports deviation. Applying OLS1, the significant coefficients bear a negative sign for MERCOSUR and CER, a positive sign for NAFTA and the EU, while the sign is non significant in the case of CARICOM. The estimates using OLS2 and Tobit coincide in sign in all the blocs except NAFTA, but they coincide in significance only for MERCOSUR and the EU.

Following the results obtained, it may be concluded that the effects of the PTAs are quite sensitive to the method chosen to estimate the gravity model; consequently, it is of great importance to determine which of the methods under consideration is the most appropriate.

Different specification tests have been designed to find the most appropriate method. Firstly, a variant of the White test has been chosen to determine the presence of heteroskedasticity in the data[12]. The test statistics, based on the R^2 resulting from OLS with a χ^2_2 distribution under H_0, throws a value of 10505.01 with OLS1 and 16993.8 with OLS2, both with a p-value of 0. Therefore, there is concluding heteroskedasticity evidence in the data; then, the estimates obtained with OLS are inconsistent and, therefore, biased.

Additional evidence is rendered by a test based on Park (1966), which seeks to determine the adequacy of the log-linear form of the gravity model. The test statistics, which has a t-student distribution under $H0_1$, shows a value of –1.28 with OLS1 and of –0.69 with OLS2, both with a p-value of 0. Given that the null hypothesis (which specifies that the log linear functional form is correct) has a value equal to 2, it may be deduced that log-linearising the gravity model is not appropriate.

Then, the tests render evidence that the estimates should not be determined by using the log version of the gravity model.

12. See Wooldridge (2002).

V. CONCLUSIONS

The methodology developed by Santos Silva and Tenreyro (2006) has been used in this work in order to estimate the relevance of the different bilateral trade flow determinants, and, also, to estimate the effects that the creation of trade blocs may have on them.

The use of the Poisson Pesudo Maximum Likelihood helps to infer that, in comparison with the estimates obtained with the log-linearisation of the gravity equation

a) The GDP and the per capita GDP are less important, with an elasticity of an average of about 0.78 in the first case and 0.14 in the other.

b) Distance is associated to an elasticity of –0.47, almost 50% smaller than that obtained with OLS1.

c) Remoteness variable shows 0.7 elasticity independently of whether the country is importer or exporter, which contrasts with the marked asymmetric results obtained with OLS and Tobit.

d) Those countries sharing common frontiers trade 53% more than those without common limits.

e) Those countries with a common language trade some 35% more while this percentage is 70% higher with OLS (60%).

f) The dummies for countries with exit to the sea show a greater effect by using Tobit. With PPML, some 25% less is traded when the importer country is landlocked, and this percentage is reduced to some 25% in the case of an exporter country, which contrasts with the asymmetry of the coefficients obtained with OLS and Tobit.

g) The estimates associated with the dummies corresponding to the different blocs offer significant differences depending on which has been the method used; then, the conclusions related to trade creation or deviation must be considered with caution.

h) If the coefficients corresponding to the three dummies in each bloc in Table 1 are added (intra-bloc, imports and exports), it can be deduced that there was gross trade creation in the Viner sense only for CER and for NAFTA, although moderately so. The most important negative result belongs to MERCOSUR, with a trade deviation which almost duplicates in significance the one corresponding to the EU, which is next in significance.

i) The results of the White and Park tests offer evidence against the OLS and Tobit methods.

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VII.ANNEX I

The countries under consideration are the following:

Albania, Algeria, Angola, Argentina, Australia, Austria, Bahamas, Bahrain, Bangladesh, Barbados, Belgium-Luxemburg, Belize, Benin, Bolivia, Brazil, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Central African Rp., Chad, Chile, China, Colombia, Congo Rep., Costa Rica, Cote D'Ivoire, Cyprus, Denmark, Djibouti, Dominican Rep., Ecuador, Egypt, El Salvador, Equatorial Guinea, Ethiopia, Fiji, Finland, France, Gabon, Gambia, Germany, Ghana, Greece, Guatemala, Guinea, Guinea Bissau, Guyana, Haiti, Honduras, Hungary, Iceland, India, Indonesia, Iran, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kenya, Kiribati, Korea Rep., Laos P. Dem. Rep., Lebanon, Madagascar, Malawi, Malaysia, Mali, Malta, Mauritania, Mauritius, Mexico, Morocco, Mongolia, Mozambique, Nepal, Netherlands, New Caledonia, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Romania, Rwanda, Saudi Arabia, Senegal, Seychelles, Sierra Leone, Spain, Sri Lanka, St Kitts and Nevis, Sudan, Suriname, Sweden, Switzerland, Syrian Arab Rep., Tanzania, Thailand, Togo, Trinidad y Tobago, Tunisia, Turkey, United Kingdom, United Status, Uganda, United Arab Emirates, Uruguay, Venezuela, Vietnam, Zambia, y Zimbabwe.

VIII. ANNEX II

Preferential Trade Agreements (PTAs)

NAFTA	MERCOSUR	CER
Canada	Argentina	Australia
Mexico	Brazil	New Zealand
United States	Paraguay	
	Uruguay	

EUROPEAN UNION (*)	CARICOM
Austria	Bahamas
Belgium-Luxemburg	Barbados
Germany	Belize
Denmark	Dominican Rep.
Spain	Guyana
Finland	Haiti
France	Jamaica
United Kingdom	Trinidad and Tobago
Greece	St. Kitts and Nevis
Ireland	Suriname
Italy	
Netherlands	
Portugal	
Sweden	

* Austria, Finland and Sweden joined the EU in 1995. However, the dummies were taken as if they had already been members over the whole period under consideration.